Electrical and Optical Properties of GaN Grown by Radical Beam Epitaxy on the (110) GaAs Surface

T. V. Butkhuzi[1], G. G. Natsvlishvili[2]*, G. I. Natsvlishvili[2]
T. G. Khulordava[1], E. G. Chikoidze[1], D. N. Peikrishvili[1]

[1]Tbilisi State University, Laboratory of Semiconductive Materials
3 Chavchavadze Ave. Tbilisi 380028, Georgia
[2]Institute of Physics, Georgian Academy of Sciences, Department of Solid State Physics
6 Tamarashvili str. Tbilisi 380077, Georgia
*E-mail: george_natsv@hotmail.com (George Natsvlishvili)

The obtaining of optoelectronic devices working in the visible or ultraviolet area of spectrum is one of the major tasks of optical electronics. The semiconductors having direct gaps, high efficiency of emitting recombination and wide gaps are essential for using in optoelectronic devices. Obtaining such semiconductors and investigation of their electrical and optical properties is very important and urgent problem. The control of electrical and optical properties of wide gap semiconductors is very problematic because of strong compensation and self-compensation caused by residual impurities and point defects. For this reason the inversion of conductivity type is problematic.

GaN is very interesting among wide gap semiconductors. The growth of GaN epitaxial layers is carried out by the method of Radical Beam Epitaxy (RBE) [1-2] on GaAs (110) surface. The mentioned method was modified for nitride growth. The structural and optical properties of grown layers can be directly related to the growth mechanisms. The GaN epilayers studied in the present work are grown on (110) surface of GaAs crystals at the temperatures 400°C, 580-600°C and 800°C. GaAs/GaN samples are investigated by Transmission Electron Microscopy. The low temperature Photoluminescence (PL) study of GaN layers is carried out.

The resistivity of GaN layers grown at T=400°C was $\sim10^8 - 10^{10}$ Ωcm. The resistivity of layers grown at T=800°C temperature was more than 10^{12} Ωcm, but the resistivity of layers grown within 580 – 600°C temperature interval was $\sim10^8 - 10^{10}$ Ωcm. After measuring thermoelectromotive force the samples grown at T=400°C and 580 – 600°C temperature interval show a weak hole conductivity. But layers grown at 800°C are insulators, because their resistivity is more than 10^{12} Ωcm. Due to specific nature of RBE technology [2], we think that a weak hole conductivity is caused by Gallium vacancy (V_{Ga}). Within 580 – 600°C temperature interval GaN with cubic symmetry (c-GaN) is obtained, while at T=400°C and T=800°C, GaN with hexagonal symmetry (h-GaN) is grown.

The peaks in PL spectra of GaN layers grown at 400°C and 800°C correspond to the edge emission of h-GaN. 3.478 eV weak emission connected with the recombination emission of free exciton is recorded. Sharp peak of 3.468 eV emission in the area of bound exciton, in our opinion, is connected with the superposition of acceptor-bond and donor-bound exciton emissions. 3.3 eV peak might be connected with transition of free electron to the level of V_{Ga} [3]. The PL spectrum of GaN layers grown within 580 – 600°C temperature interval corresponds to the edge emission of c-GaN. Peak at E=3.268 eV exists in the area of free exciton emission of c-GaN. 3.257 eV peak might be connected with the emission of bound exciton. We think that 3.08 eV emission can be connected with V_{Ga} [4]. Observation of sharp peaks in the edge area of PL spectra and absence of nonexistence of visible luminescence means that obtained GaN layers are of high purity.

By method of Radical Beam Epitaxy GaN layers of high purity, both cubic and hexagonal modification, as well as GaN insulator and hole conductivity layers were obtained. Due to specific nature of RBE technology and basing on PL spectra, we can assume that hole conductivity is connected with V_{Ga}.

References

[1] T. V. Butkhuzi, N. P. Kekelidze, D. N. Peikrishvili, E. G. Chikoidze, L. T. Trapaidze, M. M. Sharvashidze *SPIE Proc.* **3725,** 53 (1999)
[2] T. V. Butkhuzi, T. G. Chelidze, A. N. Georgobiani, D. L. Jashiashvili, T. G. Khulordava, B. E. Tsekvava *Phys. Rev.* B **58,** 10692 (1998)
[3] I. Gorczyca, A. Svane, N. E. Christensen *MRS Internet J. Nitride Semicond. Res.* **2**, 18 (1997)
[4] U. Jahn, J. Maninger, O. Brandt, H. Yang, K. H. Ploog in *Proc. 23rd Int. Conf. on The Physics of Semiconductors (Berlin, 21-26 July, 1996)* vol. **4,** 2857 (1996)